BEFORE THE
FEDERAL COMMUNICATIONS COMMISSION
WASHINGTON, D.C. 20554

In the matter of	)	
	)	
Mitigation of Orbit Debris	)	IB Docket No. 02-54
	)	
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COMMENTS OF
L'GARDE, INC.

1. L'Garde, Inc. (hereinafter referred to as "L'Garde"), pursuant to Section 1.405 of the Commission's Rules and Regulations, respectfully submits these comments in response to the Commission's Notice of Proposed Rule Making, IB Docket No. 02-54, released March 18, 2002. L'Garde agrees that it is important to address issues relating to the mitigation of space debris at this time.

L'Garde is an operating aerospace company focused on providing low-mass deployable space structures to the space community. We believe that a certain class of these devices could be quite useful for controlling and eliminating debris from orbit and thus help to mitigate the damage that can be caused by such debris, particularly in low Earth orbit.

L'Garde is pleased to offer our technical comments regarding the nature of the rules that should be adopted by the Commission. We address primarily herein our understanding of the state-of-the-art of inflatable and deployable technologies that will be useful in deorbiting space systems after their missions have been terminated, either by planned

operations or system failure. The Commission or the public may not have explicitly contemplated these technical means.

I. PRELIMINARY STATEMENT

2. L'Garde is a private company, incorporated under the laws of the State of California, with all facilities in Tustin, California. The company designs and supplies various low-mass deployable space structures and related avionics, and is particularly adept at engineering and producing inflatable systems. Our staff has extensive experience with government and commercial projects, both open and classified/proprietary. We produce systems that operate in the space environment (which ultimately could contribute to the space debris concern) and develop hardware and systems that could be used to dispose of space debris, and thus we feel qualified and compelled to comment in these proceedings on this important and urgent subject.

II. BACKGROUND

A. Fundamental Technical Aspect of Orbital Debris

3. The NPRM correctly notes, "Atmospheric drag on orbiting objects decreases dramatically as the orbital altitude of the object increases."[1] The Commission also properly claims that the orbital lifetime of space systems is affected by varying solar activity. The orbital lifetime of a space object is also a function of its ballistic coefficient (object mass divided by projected surface area). It is well known[2] that at a given orbit altitude, lower values of ballistic coefficient will decrease orbital lifetime as a result of increased drag acting on the object. As will be briefly discussed below, many of

L'Garde's systems rely on this property, and it will be shown that significant benefit could accrue to the space community if practical methods of removing space debris from Earth orbit using this property and the resultant effects could be found.

B. Development of U.S. Policy and Regulations Concerning Orbital Debris

4. L'Garde supports the adoption of the four objectives developed under U.S. Governments Standards and Practices for the control of debris.[3] Our comments in this proceeding will primarily be related to objective #4, addressing post-mission disposal of space systems.

C. International Aspects

5. L'Garde recognizes and supports the role the FCC could play in the international enforcement of the Outer Space Treaty and related international agreements, and an extension of this role for the intended purpose of mitigating the space-debris concern seems appropriate.

III. DISCUSSION

A. FCC Statutory Authority Concerning Orbital Debris

6. L'Garde believes it would be an appropriate role for the Commission to assume the added responsibility within the government of establishing and administering orbit-debris policy.[4]

7. Concerning launch vehicles,[5] L'Garde observes that although launch-vehicle booster stages are not often cause for concern, spent launch-vehicle upper stages are frequently placed (left) into orbits where operating spacecraft reside, creating a collision and debris concern. And though efforts are made to actively deplete residual propellants

in these stages (primarily liquid-propellant systems), in a few cases the past couple of decades a supposedly inert spent stage spontaneously exploded, creating a serious debris cloud. L'Garde suggests that a concerted government program to address the orbital debris concern—whether caused by spacecraft or launch systems—from a single-agency standpoint would be the preferred approach, rather than dividing the responsibility between multiple agencies.

B. Elements of Orbital Debris Mitigation

8. In the Notice, the Commission seeks general comment regarding the economic impact of the adoption of debris-mitigation procedures on the operation of commercial spacecaft.[6] L'Garde does not operate commercial satellite systems, but believes that proper application of certain types of the company's inflatable and deployable systems to certain classes of commercial spacecraft could assist operators in meeting the 25-year criteria for orbit removal suggested by this NPRM.[7] The company believes that its systems, if properly designed, are producible for relatively low cost and thus would be quite affordable to most satellite system operators. L'Garde believes minimal economic hardship would be incurred by such operators should the FCC adopt its proposed rules on de-orbiting spacecraft in this category.

9. The NRPM notes the emergence of small satellite system designs and seeks comments on whether economic incentives alone could induce operators of such systems to comply with the proposed de-orbit policy.[8] L'Garde believes that among all satellite communities, this one stands to be most affected by these proceedings. De-orbit concepts often involve propulsive techniques, but many small spacecraft (especially the more recent micro/nano/pico-classes) do not have onboard propulsion, or in many cases good

attitude control. L'Garde believes that inducing operators of certain systems in this class to ensure atmospheric re-entry within a stated period of time may be the best means of mitigating the debris concern caused by this class of space system. This could be accomplished by constraining operational orbit altitudes to some maximum level (possibly varying the limits depending on when in the solar cycle launch and mission operations occur) and perhaps by requiring that small, fail-safe, non-propulsive inflatable/deployable systems be incorporated into their system designs to ensure significant ballistic coefficient changes can be affected at end of mission life.

10. The FCC seeks comment regarding whether it should change its rules and practices regarding spacecraft orbits and mission profiles.[9] L'Garde claims little familiarity with the specific FCC practices in question, but observes that intended satellite orbits are generally well defined and communicated through various channels prior to launch (requirements documents, launch system questionnaires, NORAD coordination, etc.), and that after launch the process of knowing and controlling orbits is often a science of statistics, uncertainty and change. We believe that general policies and procedures could be put in place (by the Commission or others) to statistically ensure a certain space vehicle de-orbits within a stated period of time after launch, but to cost-effectively and precisely control and predict the time and conditions of such events (including possible in-orbit collision events) is, from our perspective, beyond state-of-the-art techniques.

11. The Commission requests comment on whether it would be appropriate to adopt the post-mission guideline (or portions of the guideline) as FCC rules and on technology developments that may affect end-of-life procedures.[10] L'Garde believes that

addressing the orbit debris concern in the context of orbit altitude ranges or regimes would be a useful practice. Further, we feel that the Commission must recognize that above a certain altitude (around 900 km), space objects have extremely long orbit lifetimes (many decades to centuries), challenging the Commission's proposed 25-year limit for the elimination of debris from orbit (or its transfer to storage or graveyard orbits). For altitudes lower than about 900 km, it's a different story. We suggest that the FCC could impose certain rules on spacecraft missions in this regime, such as a requirement to have onboard capability for modifying the space object's ballistic coefficient (and thus its orbital lifetime) or, for some larger types of spacecraft, a requirement for adequate de-orbit propulsion capability.

12. In one application of L'Garde's inflatable/deployable technology to LEO missions, L'Garde and Orbital Sciences Corporation worked together in the late 1990s to design a low-cost, optional aerodynamic de-orbit system that customers of Orbital's *Pegasus* rocket could purchase to ensure that the vehicle's third stage successfully de-orbited from LEO in 3 months <u>maximum</u>. The package's design, based on L'Garde's decades of experience producing low-mass, compactly packaged inflatable re-entry vehicle decoys, was of small volume (coffee-can sized) and low mass (<5 kg) with minimum impact on upper stage and spacecraft designs. L'Garde has also investigated applications of this technology to the higher orbital regime (>900 km), where the principal objective was to lower orbit perigee via solar pressure on an inflatable surface such that aerodynamic effects at perigee gradually induced orbital decay. These studies found that with inflatable ballutes (compactly packaged lifesaver-shaped rings that inflate to shuttlecock-like shapes) spacecraft of 100 kg mass could be de-orbited from as high as

2500 km altitude in about 15 years if the ballute diameter were around 10 m; at 1500 km altitude similar results could be achieved with a ballute diameter of around 8 m. For spacecraft twice as massive, the de-orbit time for the same sized ballute was found to be about twice as long.

13. The Commission requests comment about the applicability of these proposed rule changes to experimental and amateur satellite authorizations.[11] L'Garde understands that these vehicles typically (but not always) operate in the <900 km altitude regime discussed above, and that typically they do not have onboard propulsion capability. For such spacecraft operating below 900 km, we believe our proposed class of de-orbit technologies could be adapted to be reliable, cost-effective and integral elements of their system and mission design, thus ensuring to at least some degree of confidence that these projects would comply with the spirit and intent of the proposed policy. For spacecraft operating in higher orbits, such de-orbit capability may be problematic. Nonetheless, these types of space projects serve a useful and noble purpose and should not be precluded to operate at these higher altitudes simply because they cannot comply with the proposed de-orbit policy. The total number of such spacecraft that will ever be launched is relatively low, so the Commission should entertain the idea of exemptions during its authorization proceedings. Finally, recognizing that many projects in this class are conducted on very meager budgets, we suggest that special exemptions be granted to certain projects designing vehicles for the lower altitude regime when they can provide evidence that complying with the de-orbit requirements, though technically possible, would be cost-prohibitive.

IV. CONCLUSION

14. L'Garde believes it is positioned to make useful contributions to the mitigation of the orbital debris concern. We believe that we have raised issues in our comments that warrant further evaluation and public discourse. The proposed FCC rules have the potential of affecting all users of the space environment, with varying impact on affected projects depending on the size of the space system, its intended orbit and its financial strength. We believe the Commission's efforts toward addressing the identification and removal of space debris are worthwhile and necessary—and urgent. We also observe that the awareness within the government, commercial and university/amateur space communities of how space debris impacts projects and how these impacts can be mitigated is not as high as it should be, and thus perhaps heightened dialog and discussion is needed.

Endnotes:

1 NPRM at §7
2 1999: Wertz and Larson, *Space Mission Analysis and Design*, p. 210.
3 NPRM at §11
4 NPRM at §30
5 NPRM at § 32
6 NPRM at § 35
7 NPRM at §12
8 NPRM at §38
9 NPRM at §41 to §44 and §47 to §50
10 NPRM at §54, §55 and §57
11 NPRM at §63